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The Influence of Electrode Configuration on the Performance of Electrode-Supported Solid Oxide Fuel Cells

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The Influence of Electrode Configuration on the Performance of Electrode-Supported Solid Oxide Fuel Cells

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Unlike self-supported electrolyte cells, the electrode-supported cells always have one electrode (the support electrode) larger than the other electrode. The conventional approach is then to normalize the power output to the small electrode area. In some cases, the power density is normalized to the area of the current collector, which is even smaller than the area of the small electrode [1]. However, it is unclear whether the current density and the power density are truly independent of the cathode/anode size ratio as is implicitly assumed in the above normalization practices. The aim of this study is to investigate the change in normalized power density with the different electrode area ratios as well as the effect of the current collector area.

We fabricated NiO-YSZ anode supported fuel cell with yttria-stablized zirconia (YSZ) as thin film electrolyte and (La,Sr)MnO_3-YSZ as the composite cathode. Cells with asymmetric and symmetric electrode geometry were prepared by depositing the cathode with different areas. Two cases were studied: poor cathode/good anode cells and good cathode/ good anode cells. The poor cathodes and the good cathodes were deposited using the screen-printing technique and the Colloidal Spray Deposition process respectively (2). The symmetric cell with a screen-printed cathode had a power density of 0.45 W/cm^2 at 800°C in air/H2 as shown in figure 1. However, asymmetric cells having the same cathode material but with a significantly smaller area than the anode exhibited much higher normalized power density (figure 2). Therefore, decreasing the cathode/anode area ratio results in an increase in power density, which can be several times higher than that measured for symmetric cells. The increase of the power density with decreasing area ratio was attributed to the spreading of the current over the entire anode, which minimizes the anode polarization contribution for asymmetric cell testings. Since the fuel cell stack has essentially symmetric cells, the power density determined using asymmetric cells does not reflect stack power density. For the CSD deposited cathode, the performance improved significantly and resulted in symmetric cell power density of 820 mW/cm^2. The effect of the area ratio on the normalized power density is less pronounced.

Using a current collector with smaller area than the cathode (screen-printed) area contributes an extra enhancement that leads to apparently higher power density of 1.2 W/cm^2 as shown in figure 3. In this configuration, the normalization is done considering the area of the current collector. This normalization approach is based on the assumption that the conduction in the cathode outside of the current collector is negligible. The power density corresponding to this configuration is higher than that of the cell having the same area ratio in figure 2. This apparent difference in the performance clearly indicates that the cathode region that does not have the current collector does contribute to the current conduction.

In conclusion, we have demonstrated that large change in power density of a single cell could occur just using different electrode geometry and normalization procedures. Power density measurement using asymmetric cells does not reflect the true performance since this configuration minimizes the contribution of the support electrode polarization to the total cell voltage.

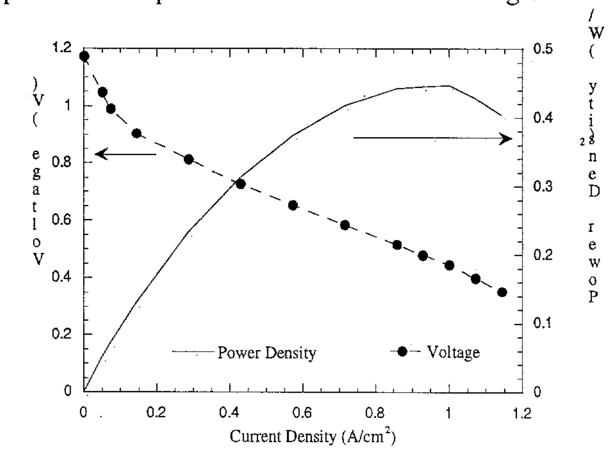

Figure 1. Symmetric fuel cell performance at 800°C

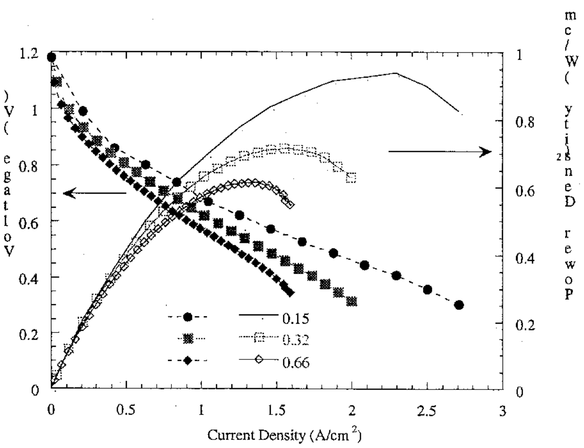

Figure 2. Asymmetric fuel cells with cathode-current collector/anode area ratios of 0.15, 0.32, and 0.66 at 800°C

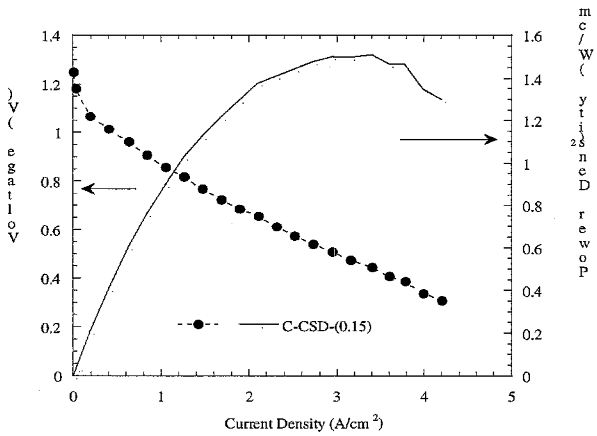

Figure 3. Asymmetric cell with a current collector area smaller than the cathode (screen-printed) area at 800°C

Reference

[1] S. de Souza, S.J. Visco, and L.C. De Jonghe, Solid State Ionics, 98 (1997) 57.

[2] A. Q. Pham, T. H. Lee, and R. S. Glass, in: S. C. Singhal and M. Dokiya (Ed.), Proceedings of the 6th International Symposium on Solid Oxide Fuel Cells. The Electrochem. Soc., Pennington, NJ. USA (1999) p. 172.

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